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The Saint Lawrence River: Flowing towards Regional Governance

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TABLE OF CONTENTS

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GREAT LAKES
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Introduction to The Saint Lawrence River: Flowing towards Regional Governance

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This compendium of articles is derived in part from a panel discussion that took place at the May 2010 River Conference, themed "Protecting and Restoring Aquatic Ecosystems through Government and Community Action" held in Cornwall, Ontario. The purpose of the panel discussion was to open a discussion on environmental governance in the St. Lawrence River region and several of those papers are contributed here (Findlay, Hudon, Griffin & McClenaghan, Twiss). Also included are other articles that provide context for the issues facing the St. Lawrence River, from historical perspectives (Parham) to the viewpoint from another continent (Ebert) where similar multi-jurisdictional and pressing environmental concerns allow for comparison of governance among large rivers. A significant contribution to environmental governance of the region have been efforts to restore ecological integrity to areas damaged by industrial activity (Ritcey, Campbell & Ridal) and the resulting institutional engagement that must be maintained to facilitate dealing effectively with future environmental concerns specific to this region (Beehler & Ridal). In contrast to areas impacted by direct industrial activity, wetland ecosystems along the river have faced stresses related to land use and water level regulation (Farrell & Distler). Also, an equally subtle but noticeable impact are invasive species and efforts to control their spread by shipping are underway (Dolors).

Each of the other great rivers that drain the Great Lakes (St. Marys, St. Clair, Detroit, Niagara) face similar issues to those presented here yet none at present are specifically included in Lake Management Plans (LaMPs) that coordinate bi-national management efforts. All of these great rivers are international waters and require coordinated international efforts to be managed and effectively protected. It is our intention to contribute to the development of regional governance of the International Section of the St. Lawrence River and use this developed model for the other great rivers in the Great Lakes system as well as similar rivers in similar systems in the rest of the world.

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Brockville, Ontario

A Sustainable Future for the Great Lakes and Saint Lawrence River Region

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*The opinions expressed in this article are those of the author and do not necessarily reflect those of the Canadian Water Network.

Canada and the United States share one of the world's most valuable natural features, The Great Lakes and Saint Lawrence River basin. At its heart lies a watershed that is one of the greatest in the world. The Great Lakes have a shoreline of more than 10,000 miles and contain approximately one fifth of the world's total fresh surface water supply. Lake Superior is the largest lake in the world by surface area and its far western end is more than 2000 miles away from where the Saint Lawrence River discharges into the Atlantic Ocean.

The Great Lakes and Saint Lawrence River basin or watershed is a major feature of the Great Lakes and Saint Lawrence River region. As distinguished from the basin or watershed, the region straddles the boundary of Canada and the United States and is defined as including all the lands and waters of two provinces of Canada, Quebec and Ontario, plus the eight States within which the Great Lakes basin is situated. Only 1% of the volume of water in the Great Lakes is replenished each year, so there is a fragile balance that must be maintained in order to sustain the watershed, the lakes and the huge resource that they represent. The sustainability challenge is basically to live off the interest that the lakes and river provide while not depleting the capital they represent.

The region is also an economic powerhouse generating more than a third of the domestic product of Canada and the United States with an economy the size of which rivals the economies of nations. Indeed, if the region were a country it's economy would rank in size behind only that of the United States, China, and India. In addition to this economic strength there are other social and environmental values that should be made explicit but which cannot be quantified quite as easily. Perhaps most importantly from a sustainability point of view, the basin is an ecologically very important region with a rich diversity of fish, wildlife and plant species supporting a population that overall enjoys a relatively progressive quality of life compared, arguably to just about anywhere else in the world.

The region is also a unique social and cultural community that is home to twenty of the world's top one hundred universities. By any measure, however it is clear that this economically strong region and its thriving society has developed based on the availability of the resources of the watersheds of the Great Lakes basin and the St. Lawrence River. This region is a vital global hub of activity and it represents a huge opportunity as well as a significant challenge for the sustainable future.

There are significant continuing and new challenges to the region's sustainability that have emerged from four centuries of human induced stresses. We find evidence of chemical, physical and biological threats to the integrity of the waters of the basin including:

- degradation of the nearshore zone due to nutrient enrichment and increasing algae development;
- continuing introduction and spread of aquatic alien species;
- significant changes to the lower food web;
- extirpation of important native species; and
- loss of coastal wetlands and other natural habitat.

These challenges have been caused by:

- nutrient loadings
- toxic chemicals
- land use practices and air deposition
- unsustainable use of energy
- hydrologic alterations
- invasive species
- loss of natural resiliency
- overstressed infrastructure
- climate change.

And they are leading to:

- A loss of buffering capacity in the nearshore areas which damages self-regulating mechanisms;
- Anoxic/hypoxic zones including Lake Erie;
- Rapid disappearance of amphipods that are the building blocks of the ecosystem;
- Multiple stresses leading to non-linear changes, ecosystem breakdown and, important consequences for human well-being and sustainability.

The management challenge we face is the need for a fresh, integrated watershed based regional initiative that will protect and improve the ecosystem integrity of the region's Great Lakes and Saint Lawrence River watersheds for future generations based on a positive, progressive, prevention-oriented forward-looking view towards future sustainability. We need a new kind of distributed, collaborative approach to governance that helps all of our existing multiple levels of government do the jobs for which they are best suited and mandated to deliver.

A New Approach is Needed for Sustainability

A new approach is needed with new ideas, new partnerships and new institutions that will create a re-energized, positive, combined, basin-wide, forward-looking Great Lakes Saint Lawrence River agenda that focuses on the water and ecosystem of the basin as it addresses the social and economic sustainability of the region.

The new approach must first be based on a shared bi-national vision for the sustainability of the region, including Tribes and First Nations. One such vision statement has been developed by members of the Great Lakes Futures Roundtable, a group of people who live in the region and who have a range of experience and responsibilities in both public and private sector organizations and institutions but who have gathered as individuals through the Roundtable process, not as representatives of their respective employers. A copy of the Great Lakes Futures Roundtable October 2007 Great Lakes Saint Lawrence Vision, Mission and Goals is appended to this article.

Imagine a Park

So how do we move ahead and begin to bring such a vision to reality? One way to help to realize the Vision is to perhaps imagine a park. Really - a park, you say? Well, what we likely need to achieve is something that has the following attributes and describing them as the elements of a park may help us get our heads around how to perceive and then achieve this vision. We need a Park that has the following attributes:

- A bi-national sustainability region (international including Tribes and First Nations)
- A global identity
- Shared Vision, Plans, Goals
- Resources, timelines, accountabilities
- A shared new enterprise based on enhancing our amazing shared asset; our freshwater.

How will we feed, house, transport and support the population that will live in our new sustainability park? Achieving the Vision will depend on having elements such as the following:

1. Green Cities and Great Lakes: Cities are where the people will be and Green Cities need to develop with green economies. Cities in the "park" will need to be able to accommodate growing populations with well-planned and efficient urban neighbourhoods.

2. Bigger Than a National Park: Canada and the U.S. can combine forces to create a bi-national park that includes cities, towns and villages as well as natural areas. It will be a waterfront park that includes 11,000 miles of waterfront; a park that welcomes world travellers.

3. Great Minds and Great Lakes: How can our education institutions establish a collective forum that would explore how the region can realize a sustainability vision? How can we engage students at all levels in the future of the region?

4. Blue is the New Green: We need to ensure swimmable, fishable waters and understand and adapt to the effects of climate change on our water systems.

5. Tapping Renewable Energy: How will we energize our Park renewably and sustainably, beyond carbon based fuels?

6. Achieving Mobility: How can we transport ourselves and our goods efficiently and sustainably and encourage post carbon transportation innovation?

7. We need to become leaders in Climate Change policy, technologies, innovation, mitigation and adaptation.

8. The food capital: how can we feed ourselves sustainably?

9. A New Approach to Governance: Achieving such a vision will not be possible if we expect

sustainability to be achieved by our local, state, provincial and national governments as we know them, acting alone for us; we need a kind of societal project that captures the imagination of people in our cities, industry, schools, farms, industry and among leaders and innovators, everywhere including of course, all of our levels of government.

This new approach to governance needs to:

- take an inclusive, distributed, watershed based approach;
- stem from a stewardship ethic that motivates people to contribute and get involved;
- have a knowledge base that informs effective decision-making based on an open and distributed approach to data and information access;
- provide the financial investment to ensure full implementation of the new approach.

In conclusion, based on a vision of sustainability the challenge to all in the region is to imagine the combined Great Lakes and Saint Lawrence River region as a “park” or sustainability region and to work ahead through our daily enterprises to imagine, realize and help establish a sustainability framework approach aimed at facilitating such a vision on a distributed basis.

Acknowledgement: This article would not have been possible to write without the collaboration and good will and contributions that the author is delighted to share with the members of the Great Lakes Futures Roundtable and collaboration with friends at Skidmore, Owings and Merrill, in Chicago.

Coastal wetland in New York along the International Section of the St Lawrence River.

Appendix 1

Great Lakes Saint Lawrence Vision, Mission and Goals

VISION

The Great Lakes and St. Lawrence River region is one where people, the environment, economy and cultures are healthy and thrive for generations to come.

MISSION

The people of the region will act as stewards to use and enjoy their natural treasures in ways that care for and improve them.

GOALS

Social

Social institutions give people the ability and knowledge they need to cherish and safeguard the Great Lakes and St. Lawrence River, the skills and capacity to be productive and contribute, and the opportunity to enjoy a good quality of life.

- Education. The region has an educational system that teaches people to appreciate and respect the unique environment in which they live, and gives them the skills and capacity to participate in a knowledge-based economy.

- Health. Both the natural and built environments foster good health for all, high quality care is accessible to those who need it, and well-being is enhanced by employment, housing, recreational and cultural opportunities.

- Engagement. Individuals and public sector, private sector and non-governmental organizations actively work together to improve conditions in the region.

Environmental

A robust ecosystem provides the basis for a diverse and healthy community of plants, animals and people, as well as strong economic and social systems.

- Natural Environment. The biological, physical and chemical integrity of the Great Lakes and St Lawrence River supports natural biodiversity and ecosystem functions.

- Adaptation to Change. People of the region engage in global efforts to mitigate social, economic and environmental change, and apply their combined resources to address local impacts.

Economic

The Great Lakes and St. Lawrence region has a vital economy and business climate that delivers quality goods and services to residents and beyond. There are job opportunities in all sectors with productivity and well-being assured through the wise use of natural and human resources, technology and capital.

- Business climate. Revitalised natural and built environments increase the region's attractiveness, with investments being made in enterprises that share the Vision for the region, underpinning social and environmental goals

- Employment. A workforce that is highly educated and motivated is attracted to the region by its environmental quality, social systems and the opportunities provided by its vibrant economy.

- Infrastructure. People and goods move with great efficiency and the lowest impact on the environment. Production is supported by sustainable use of available natural resources.

Recognizing the many interests (social, cultural, economic, environmental) and interdependencies among organizations in the Great Lakes and St. Lawrence region, this vision can only be achieved by organizations working together.

Nuclear power plant at Darlington, Ontario, along the north shore of Lake Ontario.

Governance along the St. Lawrence River: Expanding beyond Remedial Action Plans

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The formal history of water management and legislation within the Great Lakes-St. Lawrence River Basin begins in 1909. It was in this year that the Boundary Waters Treaty was signed between Canada and the United States. Besides delineating all navigable waters as 'free and open', the International Joint Commission (IJC), a commission with equal representation from Canada and the United States, was established to oversee disputes occurring within transboundary waterways. This framework persists to this day, and is the binational mechanism for border water issues (IJC 2009).

As development escalated throughout the past century, with such notable events as the construction of the Moses-Saunders power dam (1958), industrial facilities, intensive agriculture and the St. Lawrence Seaway, environmental degradation ensued. This arose from changes to the natural landscape including the hardening of shorelines and loss of wetlands, metal and chemical contamination such as mercury and polychlorinated biphenyls (PCBs), and the introduction of invasive species, among other issues. Consequently, the ecological characteristics of the Great Lakes-St. Lawrence River along with the residents' use values were affected by these tangible changes; changes that included bioaccumulation of contaminants, nuisance algal growth, and added costs to agricultural and industrial production. In 1972, the Basin community through the IJC resolved themselves to proactive actions to mitigate these problems. What resulted was the creation of the Great Lakes Water Quality Agreement (GLWQA).

Initially, the GLWQA focused on phosphorus loads, which was the nutrient principally responsible for eutrophication of lake water – one of the most publically visible consequences of water pollution. At that time, the IJC was the coordinating body tasked to collect, analyze, and disseminate water quality data, as well as to provide advice and recommendations to those areas not achieving the prescribed water quality standards. By 1978, concern expanded from bacterial and 'naturally' occurring contaminants to toxic and hazardous pollutants, which originated or were isolated to specific areas known as 'hotspots' of environmental contamination. In turn, those 'hotspots' were categorized as Areas of Concern (AOC). An AOC was formally described as "a geographic area that fails to meet the General or Specific Objectives of the Agreement [GLWQA] where such failure has caused or is likely to cause impairment of beneficial use or of the area's ability to support aquatic life" (IJC 1989). In total, forty-three locations throughout the Great Lakes-St. Lawrence River Basin were designated as AOCs, which spanned from Lake Superior to the St. Lawrence River (Fig. 1, US EPA 2009). In 1987, the GLWQA was amended to include a formal commitment on behalf of both Canada and the United States to undertake Remedial Action Plans (RAPs)

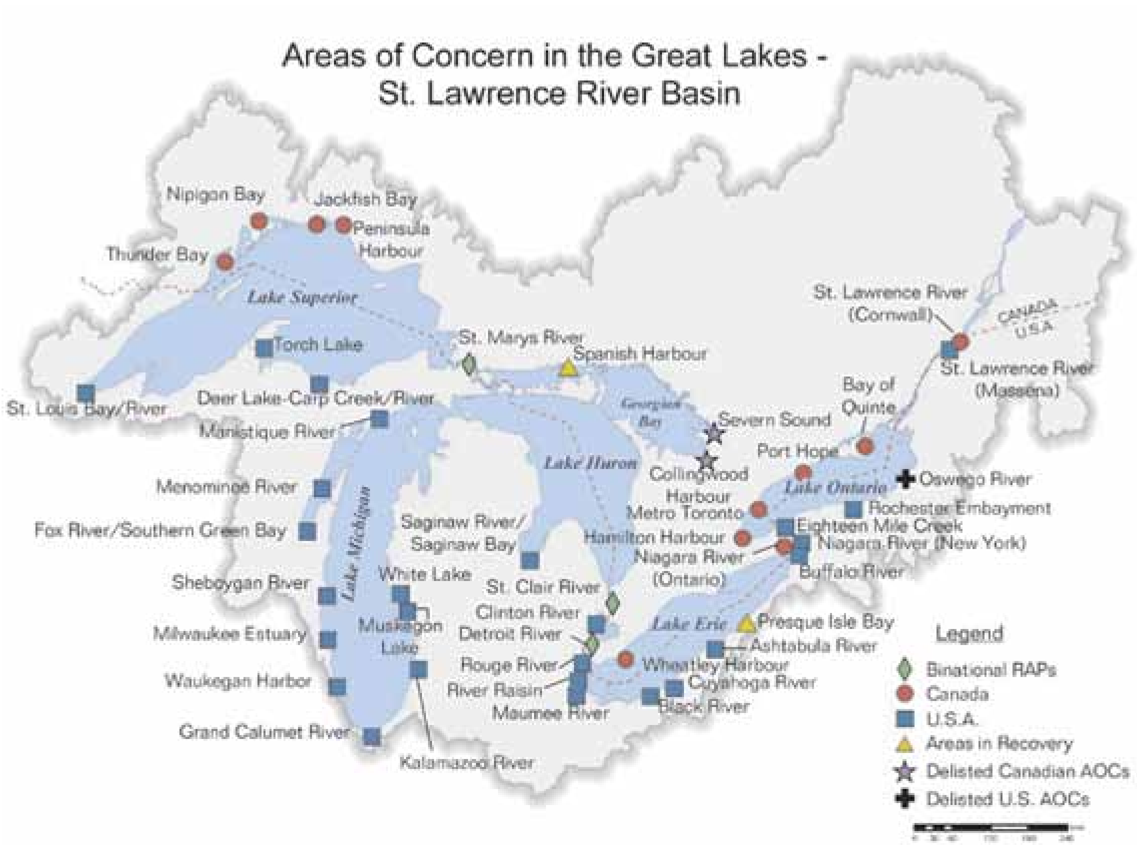

Figure 1. Map of the 43 Areas of Concern for the Great Lakes St. Lawrence River Basin

for each AOC in order to restore the ecological and, by extension, the social integrity of the affected places (IJC 1989).

Embedded within the RAP framework are two predominant concepts relevant to the following discussion. These are an ecosystem approach and an emphasis on public consultation. The ecosystem approach applied a systematic and comprehensive analysis to the restoration process reflecting the change from isolated forms of inquiry and remediation to that of complexity and interdependency. Attention to public consultation was another shift from traditional forms of environmental management. As opposed to constraining the process to solely state and industry relations, those living within the AOCs were to be formally involved in the restoration process.

This article focuses on one specific AOC: the St. Lawrence River. This AOC is essentially one of a limited number of binational AOCs, which means that both Canada and the United States are subject to restoration efforts within that locale. It is unique amongst binational AOCs (Fig. 1) in that two different RAPs are involved: one on the Canadian side of the border and the other on the American side. There is added jurisdictional complexity due to the extension of the St. Lawrence River into the Province of Quebec and the presence of another nation, the Mohawks of Akwesasne, geographically located within the heart of the restoration area (Fig. 2, IJC 2003). And lastly, the Canadian RAP is presently in the consultation process to determine whether the area should be submitted for delisted status and hence be removed as an AOC or become an Area in Recovery (Sproule-Jones 2002).

For the analysis of this AOC, the chief sources of information came from government documents, reviews

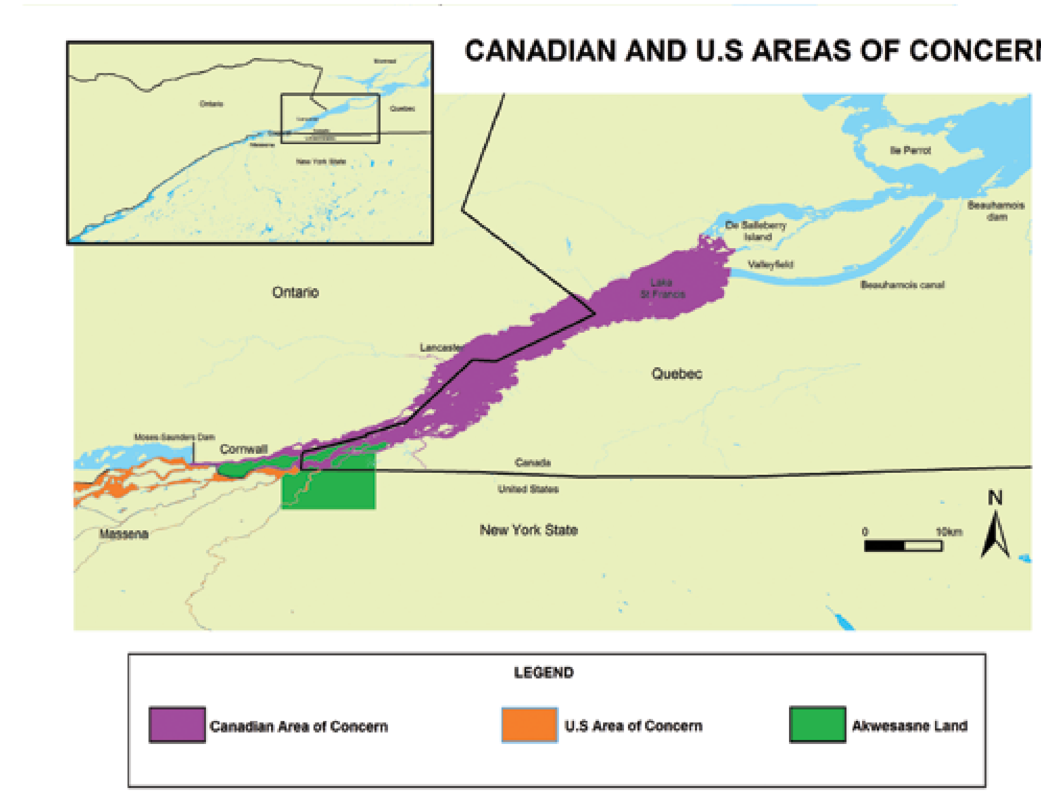

Figure 2. Map of the St. Lawrence River Area of Concern.

of journal articles on ecosystem-based approaches to environmental and watershed management, the Great Lakes Water Quality Agreement and remedial action plans, and environmental governance including adaptive management literature. The literature review was supplemented by participant observations at restoration council meetings, conferences, and workshops. Furthermore, interviews were conducted with twelve members of the St. Lawrence River RAP who represented a diversity of interests involved in the RAP process. The interviews underwent content analysis as motivated by the literature review.

Development of the St. Lawrence River AOC

Although Canada and the United States were mutually mandated under the GLWQA to establish and execute RAPs, the domestic political structures shaped the restoration process. Under Canada's Constitution Act, provinces are granted rights over the land and water. Therefore, the binational agreement lacked force without the consent of the province, in this case, the Province of Ontario. Therefore, the federal and provincial governments created the Canada-Ontario Agreement (COA) as the formal mechanism committing the province to restoration activities (Environment Canada & Ontario Ministry of the Environment 2007). In the United States, rights are reversed. The federal government holds authority over the land and water thereby committing states to restoration endeavors without their individual consent. However, the governors of the eight states that bound the Great Lakes-St. Lawrence River Basin created the Council of Great Lakes Governors to jointly strive toward environmentally sound economic development (Durfee 1995).

Since the St. Lawrence River RAP is effectively a binational RAP, the Canadian lead agency is the federal government through Environment Canada (EC) with provincial representation from the Ontario Ministry of the Environment (MOE). For the United States, the lead agency is the New York State Department of

Environment Conservation (NYDEC) overseen by the United States Environmental Protection Agency (USEPA). With support from the Quebec region of Environment Canada and the Mohawk of Akwesasne government, the federal, provincial, and state agencies collaborated with one another on environmental contamination research within the St. Lawrence River. As the extent of the contamination became clearer among the parties, the RAP divisions along the River also became more pronounced.

While research was being conducted by the governmental agencies, the public on both sides of the St. Lawrence, in Cornwall, Ontario and Massena, New York, were informed of the RAP purpose and process. Upon completion of the initial consultations, citizens wanting to become active in the restoration process were assembled into advisory committees. Within Cornwall, it became known as the Public Advisory Committee (PAC) and the Citizen Advisory Committee (CAC) in Massena. The committees consisted of individuals from industry, agriculture, education, landowner associations, anglers, concerned citizens, and so on. As the names suggest, the PAC and CAC were designed to advise the governmental RAP teams on the preferences for restoration. Initially, the PAC and CAC consulted with one another under the auspices of a St. Lawrence River Restoration Committee until disputes arose among members and the committee was disbanded. From then on, there was no formal mechanism bringing the public from Canada and the United States together.

By 1990, the U.S. RAP completed their background assessment with the publication of the Stage 1 report and the following year published the Stage 2 report delineating the actions for remediation. This included the disbandment of the Massena CAC since their advisory role was completed. Meanwhile, the Canadian RAP progressed at a slower pace publishing their Stage 1 report in 1992 and then five years later in 1997 their Stage 2 report. Therefore, the direct public engagement persisted for an extended 5 years on the Canadian-side of the border. Furthermore, the PAC motivated the creation of the St. Lawrence River Restoration Council, which became the decision-making forum for the Canadian restoration (New York State Department of Environment Conservation 1990).

While each of the RAPs created their own restoration recommendations, the end goal remained the same. This is to "restore, protect, and maintain the chemical, physical and biological integrity of the St. Lawrence River ecosystem… and protecting the downstream aquatic ecosystem from adverse impacts

North channel of the St. Lawrence River between Cornwall Island and the old shipping canal with a view of the Moses-Saunders power dam upstream.

originating in the Akwesasne, Cornwall-Lake St. Francis and Massena Area of Concern" (St. Lawrence RAP Team 1992). Therefore, even though the impetus for restoration was binationally endorsed and created, the effect became a place-based restoration process with regional engagement. Even within the initial goal, there is a recognition that the effects are not isolated to the AOC region, rather it is connected to all those in the Great Lakes-St. Lawrence River Basin especially those at the receiving end.

From Two RAPs to One River through Governance

As the Canadian RAP at Cornwall considers the culmination of a formal RAP process, questions begin to arise about what happens next. Besides devoting attention to the ecological restoration of a particular region, strong relationships have been formed, knowledge gained, and a desire to continually improve the regional ecological, social and economic prosperity of the region persists. However, beyond these integral features is the impetus to move beyond the confines of the RAP, beyond the set limits and borders, and in so doing integrate with other organizations and jurisdictions addressing similar concerns (Waltrner-Toews and Kay 2005).

Although the RAP process has not always been integrative, as is witnessed through the division of the two RAPs, the tug-of-war for the Mohawks of Akwesasne having to liaise with two RAPs, and the lack of coordination with the Province of Quebec, these shortcomings may be mitigated through a St. Lawrence River-wide governance structure.

Governance is the mechanism for change; in a broad conception, it is a decision-making process that is organizationally structured to support collective action among government and nongovernmental entities (Brandes, et al 2005). It facilitates an inclusive engagement among varying perspectives and positions surrounding a common issue (Plumwood 2002). In the context of RAPs, governance afforded those living within the region, federal, provincial and state governments, industries, First Nations, academics, and citizens the opportunity to construct and engage in the direction taken to maintain environmental integrity along the St. Lawrence River. Through an evolution of the present governance form, decisions all along the St. Lawrence River may be harmonized or at the very least presented and discussed among those that will or may be affected at present or in the future.

The concept of a St. Lawrence River wide organization was discussed at the Mighty St. Lawrence River workshop held in Brockville, ON, in December, 2009. Forty-eight individuals from federal, provincial, and municipal governments, research institutes, First Nation communities, non-governmental organizations, conservation authorities, and interested citizens converged to envision possibilities for an integrated future of the St. Lawrence River. Breakout-sessions addressed considerations for the process and content of a prospective St. Lawrence River strategy, and the future research needs to support and expand on the scientific monitoring efforts undertaken in the RAP processes (French Planning Services Inc. 2009). These issues were further discussed at the 18th Annual International Conference on the Great Lakes/St. Lawrence River Ecosystem in Cornwall, Ontario with representatives from Quebec, Ontario, New York, and First Nations. The next step is actualizing these discussions through the establishment of a river-wide network. Networks evolve with time, as the RAPs have, but what makes this network unique is the foundation in place-based, cross-boundary, jurisdictionally integrative coordination that relies on interested persons beyond government structures though working alongside them to effect change (Hahn et al. 2009).

Conclusion

This article began with a discussion of cross-jurisdictional water management through legislation. The prominent piece being the GLWQA, which was progressive for its time due to its inclusive and comprehensive nature. It was comprehensive through the ecosystem-based approach, and inclusive by its emphasis on public participation. From the formal arrangement, water management and specifically management of the St. Lawrence River resides in every individual and across spatial and jurisdictional scales. Rather than relying on a single unit of society, RAPs have shown that concerted effort builds solidarity and impetus for further change by not only focusing on the place one lives, but including those that live up and downstream.

Acknowledgments

We thank Michael Twiss for reviewing the article and providing constructive comments. Thanks also to the interview participants and members of the St. Lawrence Restoration Council especially the RAP coordinators for their insights and dedication to the RAP project. Last, we would like to acknowledge Queen's University's School of Environmental Studies as well as the Aquatic Ecosystem Health Laboratory for their generous support, and the St. Lawrence River Institute of Environmental Science for hosting the international conference where this research was originally presented.

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The St. Lawrence River Flowing Forward Together
Remedial Action Plans for Areas of Concern and their role in SLR Governance

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Often referred to as the 'mighty river' the St. Lawrence River is approximately 1,197 kilometers in length and drains one million square kilometers of the Great Lakes Basin (GCR 2007, CE 2010). Considered a relatively young river geologically, its bed was exposed some 10,000 years ago during glacial melt (CE 2010). This river's outflow originates between Kingston and the north bank of Wolfe Island and flows to the tip of the Gaspé Peninsula in Quebec.

The St. Lawrence River has played an important role in the course of the historical economic, social and cultural development of Canada and the US. Accessed as an exploration route early on, the areas rich natural resources made it an ideal area for settlement.

Today over eight million Canadians and Americans live along the shores of this complex river system that flows through two provinces and forms an international boundary between the United States and Canada (Concordia 1997). The river system supports an array of activities including mining, agriculture, forestry, power generation, shipping, drinking water, commercial and sport fisheries and recreation and tourism. The river is also ecologically complex and its diversity of rich habitat is home to numerous plants, plankton, benthic organisms, fish, amphibians, reptiles, birds and mammals.

Unfortunately, development along the river has led to negative environmental impacts such as (but not limited to) organic wastes, microbial contaminants, organic chemicals, and species loss, habitat loss and exotic species. Recognizing the need to protect the shared waters of the Great Lakes and St. Lawrence River, the International Joint Commission (IJC) was formed following the Boundary Waters Treaty of 1909. In 1972, both the United States and Canada signed the Great Lakes Water Quality Agreement with the goal of cleaning up the waste water and controlling sources of pollution. The most environmentally degraded areas around the Great Lakes were identified as Areas of Concern (AOCs) and following extensive site assessments Remedial Action Plans (RAPs) were put into action to begin the restoration process. Annex 2 of the Great Lakes Water Quality Agreement between Canada and the United States outlines the commitment of both countries to an "ecosystem approach" for restoring and protecting environmentally degraded areas of the Great Lakes (GLWQA 1987).

The St. Lawrence River was identified as one of five bi-national AOCs. Two distinct RAP's were developed; one for the St. Lawrence River (Cornwall) AOC and the other for St. Lawrence River (Massena) AOC. The decision to develop two separate RAPs was made because of the differences in the issues to be addressed (i.e., PCB contamination on the Amercian side and Hg contamination on the Canadian side) and limited cross-border spillover from contamination issues due to the prevailing strong currents of the St Lawrence. The Cornwall AOC encompasses an 80 kilometer stretch of shoreline from the Moses Saunders Dam in Cornwall to the Beauharnois Dam in Quebec. Twelve tributaries and their watersheds are also included primarily due to nutrient and habitat loss concerns. Alternately, the Massena AOC originates above the Moses Saunders Power Dam at Massena and extends 24 kilometers downstream to the international border. Portions of three rivers, the Grasse, Raquette and St. Regis are also included (US EPA 2009).

In order to implement the restoration goals that were developed through the RAP for the Cornwall AOC, the St. Lawrence River Restoration Council (SLRRC) was formed in 1998. The SLRRC is comprised of federal, provincial and municipal levels of government, the Mohawks of Akwesasne, public interest groups, Conservation Authority, various local industries and local scientists. Over the course of twelve years, the group has successfully addressed the key environmental issues within the area by focusing on the delisting criteria and recommendations set out in the RAP Stage 2 document and is currently assessing whether the AOC can be removed from the list of one of the most toxic hotspots around the Great Lakes. Following an initial stage dominated by government agencies and industries implicated in the Superfund Process, a similar group, the Remedial Action Committee (RAC), was formed for the Massena (AOC).

Developing a St. Lawrence River Network

Although the RAPs were developed to address many of the legacy contaminant issues that affected the AOC, new environmental pressures continue to affect the Great Lakes and St. Lawrence River system. In order to effectively address these rising concerns, a collaborative approach with more broad based objectives in comparison to those set out through the RAP process, on a broader geographical scale is necessary. In Quebec, under the St. Lawrence Plan, a plan for a more integrated management of the St. Lawrence is underway in order to confront emerging environmental issues through a participative governance approach (St. Lawrence Plan 2007). Increased involvement of US and Canadian government researchers is planned through the Collaborative Science and Monitoring Initiative (CSMI) which has been developed to focus research on a rotating basis on each of the Great Lakes. For the first time, the research needs of the St Lawrence River are being considered to be included with the Lake Ontario rotation slated for 2013. To help develop the research needs, an International St. Lawrence River node for the Great Lakes Regional Information Network has been proposed (Twiss, 2010).

A collaborative approach to link community and research needs for the International portion of the St. Lawrence River is currently being discussed. This approach has stemmed from a recognition that there is a need for community involvement to continue to protect and restore the integrity of the international St. Lawrence based on the achievements and experiences gained locally through the AOC process.

To these ends, the SLRRC in partnership with Clarkson University and the St. Lawrence River Institute of Environmental Sciences held a workshop in December 2009 in Brockville, Ontario titled "The Mighty St. Lawrence, People and Partnerships – Developing a Holistic Approach for Working Together and Managing the River".

Following the concept that knowledge is acquired through collaborative knowledge gathering activities (St. Lawrence Plan 2007), participants representing both the United States and Canada from multiple environmental sectors including; federal, state and provincial governments, Mohawks of Akwesasne and St Regis, local decision makers, academia, and public interest groups were invited to offer input on potential mechanisms to promote collective responsibilities and shared visioning for future management of the St. Lawrence River. The workshop focused on the partnerships that currently exist along the St. Lawrence and explored possible mechanisms to broaden community based partners and engage a wider support network with scientific roots that could assist in establishing riverwide priorities and guiding future actions.

Overall workshop participants envisioned a riverwide strategy led by a central steering committee that would synthesize and prioritize existing information regarding the river, identify key stakeholders, generate priorities and actions and acknowledge potential funding resources. The strategy would be developed using a bottom-up approach similar to that adopted by the Lake Huron-Georgian Bay watershed (Environment Canada 2007) and be based on a realistic, practical and measurable plan.

Challenges and Obstacles

There are a number of challenges presented when developing a community-based governance strategy for an environmental system as widespread and complex as the St. Lawrence River. The first involves defining the geographic scope of the strategy. The geographic scope will influence key partnerships and the goals and priorities for the overall initiative. That being said, setting achievable goals and determining the mechanisms to measure the success of those goals efficiently will be a challenge faced by the steering committee (Pellizonni 2004). Second, establishing a common path for action, restoration and protection in a strategy that transgresses regional and international boundaries and are thus driven by different legislative and administrative processes could make it difficult to achieve efficient and effective outcomes. The variety of environmental mandates represented within a diverse committee of partners may also lead to difficulties in developing a strategy that is broad based but also captures regional environmental concerns and goals. In the St. Lawrence Plan, in order to achieve a shared vision, the St. Lawrence River was divided into regions with a representative that sits on the central steering committee.

In order for the strategy to gain merit, particularly with upper levels of government agency management, it will need to be accountable. Thus open and current communication and information sharing between partners will be necessary. A web-based portal to share information driven by a central contact will be necessary. Annual progress reports should be prepared and distributed to all partners, funders and the community at large. A venue such as the annual conference on the Great Lakes and St. Lawrence River Ecosystem hosted yearly by the St. Lawrence River Institute of Environmental Sciences in Cornwall would be an ideal opportunity for partners to gather and share information.

Lastly, the mechanisms for funding opportunities and delivering on the ground projects under a collaborative approach will need to be determined.

Towards the Future of a Great River!

The St. Lawrence River is a magnificent river that has important ecological, cultural and commercial ties on an international scale. At risk to similar threats being faced throughout the Great Lakes Basin, a unified riverwide framework for action would provide a solid foundation for future protection, restoration and research opportunities to occur.

Although it is premature to report on the intricacies of how a community-based framework for the International St. Lawrence River would be delivered, it is essential to recognize that for effective, long-lasting conservation to occur it will need to be based on principles that promote collaborative, science–based approaches through inclusive decision making processes (Environment Canada –Lake Huron, Lemos and Agrawal 2006).

It is important to recognize that the mechanisms for a collaborative governance strategy are based on complex and dynamic relationships. A steering committee made up of representatives from key collaborators will need to be established to guide the process and common goals will be required to develop an effective strategy.

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The St. Lawrence Seaway and Power Dam Project: Construction Feat – Economic Failure

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For five decades, Canadian and American engineers, politicians, and transportation lobbyists, debated the cost and feasibility of the construction of the St. Lawrence Seaway and Power Dam. While supporters promised that the waterway would provide a cheaper transportation route for Great Lakes manufacturers, its completion threatened the livelihood of American ports and railroads on the eastern seaboard and in the interior of the United States. When the United States became the leading global superpower after World War II, manufacturers and national government officials recognized the need to be able to transport products and possibly military equipment to Europe as well as the growing demand for electricity from new military and consumer industry owners. Additionally, fed up with the continuing delays of the U.S. to participate in a joint construction venture, Prime Minister Louis St. Laurent and Minister of Transport Lionel Chevrier proposed that Canada build all of the facilities on their side of the border. In light of this turn of events, opponents' arguments fell by the wayside and the Wiley-Dondero bill funding and outlining the construction and maintenance of the completed waterway and power facility quickly passed both houses of the United States Congress in 1954.

While promoted after the Second World War as a Cold War initiative to garner congressional approval, historically local and state officials had rallied for the waterway and new power source as a means of improving the economic outlook of Massena, New York and surrounding areas. However, several factors cast an ominous shadow on these claims. Firstly, the project designers only proposed improving existing ports and did not provide provisions for additional access points. This coupled with the fact that state and federal officials did not suggest the construction of new alternative land routes offering potential manufacturers major highways to transport raw materials and finished goods by truck, stymied efforts by local economic developers to convince industrialists to locate new plants in the region. Secondly, the power project in the United States held precedent as a means to supply a few local manufacturing plants, but mainly to illuminate largely metropolitan areas, including New York City. Finally, the issue that greatly affects the operation of the waterway currently is the obsoleteness of the Snell and Eisenhower Locks and the shallow channels based on the contractors use of 1941 plans, a stringent timetable, and poor concrete integrity. Collectively, these factors leave the future of the waterway uncertain. Regardless, the construction of the project stands as one of the major public works' accomplishments of the twentieth century.

Location and Key Facilities of the St. Lawrence Seaway and Power Project

Located on the U.S. - Canadian border between Montreal and Duluth, Minnesota, the St. Lawrence Seaway and Power project remains the largest inland waterway ever completed. In 1954 construction commenced on the five sections of the endeavor, three of which were located exclusively in Canada. The completion of the project required the cooperation of New York State and Ontario provincial officials along with four lead agencies, the federal governments of Canada and the U.S., and their contractors. Each section included locks, channels, and dams the construction and eventual operation of which had to be coordinated among many entities. The completed project created a navigable waterway from Montreal, Quebec to Lake Ontario, raising Lakers 225 feet from Montreal to Lake Ontario; tamed the existing rapids for power production; and, bypassed the hydro and control dams with locks and canals. The St. Lawrence Seaway project has been called the eighth wonder of the world, a power-waterway development so great that it defied comprehension. Carleton Mabee added in The Seaway Story, "The job was diverse. It meant seizing land, lifting bridges, moving houses, railways, and factories out of the way, it meant building canals, dikes, dams, and locks, and it meant replanning old towns and creating entirely new towns."

Long Sault Dam

Key Statistics of the St. Lawrence Seaway and Power Project

Governments: United States, Canada, New York State, and the Province of Ontario

Agencies: Ontario Hydro, The Province of Ontario, Power Authority of the State of New York, U.S. Army Corps of Engineers, St. Lawrence Seaway Authority, and the St. Lawrence Seaway Development Corporation

Length of Political Debate for Project Approval: 50 years

Location: 265 miles between Montreal and Duluth, Minnesota
Dates of Construction: 1954 - 1959

Equipment and Materials: $75 million in on-site equipment, six million cubic yards of concrete, and the dredging and excavation of 360 million tons of glacial till, clay and bedrock

Total Cost: One billion dollars

2010 Freight as of August: 18,711 thousands of tons of cargo on 1,984 vessels

Lock Size	800 x 80	1000 x 110
Workforce	22,000	39,000
Channel Depth	27 feet	45 feet
Years to Complete	5	8

Comparison to Panama Canal

	Seaway	Canal
Length	114 miles	50.5 miles
Lock Elevation	580 feet	85 feet

The Robert Moses – Robert Saunders Power Dam, the central structure of the St. Lawrence Seaway Power Project, impacts peoples' everyday lives, but operates in relative obscurity. Jointly built by American and Canadian contractors, the structure cost $600 million, spans 3,230-feet, and stands 167-feet-high. The two equal sections contain sixteen turbines with a combined annual power generation capacity of 2.2 million horsepower. Each country's contractors constructed a power plant at the beginning of its section housing transformers to send power to adjacent transmission lines. Workers built the structure with 1,890,000 cubic yards of concrete, 116 million pounds of reinforced steel, and 15 million pounds of structural steel. Annually, the American section of the dam produces 900,000 kilowatts of electricity – enough to light Washington, DC. Overseen by the New York State Power Authority under a 50-year license renewed in 2003, the facility is currently undergoing a $281 million life extension and modernization program replacing all 16 turbines and rebuilding or renovating the remainder of the facility.

The Long Sault Control Dam, another major aspect of the power production component of the project, is located in the main channel between Barnhart Island and the Canadian mainland. The dam closed off the channel near Barnhart Island. Contractors completed the spillway dam exclusively on the American side, three and a half miles upstream from the power dam. The 2,960-feet long, 145-feet high, Long Sault constructed of five million pounds of reinforced steel, four million pounds of structural steel, and 660,000 pounds of concrete, controls the level of water in the power pool.

Equally important is the Iroquois Dam completed between November of 1955 and March of 1958 that regulates the water level on the seaway by altering the outflow of the Great Lakes. Situated 25 miles upstream from the Robert Moses - Robert H. Saunders Power Dam, the structure spans the width of the St. Lawrence River from the U.S. mainland near Waddington, New York to Iroquois Point on the Canadian shore. The $14.4 million structure is comprised of 194,920 cubic yards of concrete, a series of piers and sluiceways, and two 320-ton gantry cranes that operate the structures thirty-two lift gates.

The two American locks, the Snell and the Eisenhower and the channel dredging remains the most complicated and controversial undertakings on the project and due to antiquated designs and size restrictions were not only obsolete at the time of their completion, but also threaten the future of the waterway. In 1954, Canadian freight companies feared the loss of business if ships' captains could enter the Seaway directly from the Atlantic Ocean and the size of existing locks on the Canadian side dictated width and depth of these endeavors.

The Wiley -Dondero Ship Channel, a 10-mile bypass waterway, assists ship captains in navigating around the power dam and houses two 860 by 80-foot locks – the Snell and Eisenhower. The Snell Lock lifts vessels 49 feet to and from Lake St. Francis. The $26,753,000 facility can accommodate ships up to 768 feet in length. The Eisenhower Lock allows ships to bypass the main power dam. Workers placed the first concrete on July 11, 1956 and completed the structure in October of 1957. The side walls reach 115 feet at

their highest point and the total width of the basin is 80 feet. At a cost of $20,172,000, workers excavated 3,000,000 cubic yards of material, poured 535,000 cubic yards of concrete, and welded over 4,000 tons of reinforcing and structural steel.

The second largest earth removal operation in the world during the 1950s, the Thousand Islands Channel Improvements, encompassed a 68-mile-stretch of the river, created a steady flow to the power pool, and removed 15,000,000 cubic yards of earth and rock from Galop and surrounding islands to eliminate the meandering course of the river. However, the shallowness of the channel limits the size of ships that can utilize the waterway and result in many vessels running aground.

Design problems surfaced even before the awarding of the first contract and continue to plague the seaway into the present day. Due to the short span of time between the passage of legislation and the beginning of excavation, engineers had not completed the plans for any of the seaway or power dam components. Also, an expanded program of drilling and core samples by the U.S. Army Corps of Engineers (Corps) uncovered substantial amounts of marine clay and glacial till near both locks and in all designated dredging sites. Many contractors did not comprehend the difficulty of excavating marine clay and glacial till and low bid their aspect of the project. Contractors reported extra costs and demanded extensions when they needed to blast most of the till and find creative ways of disposing of the clay. The shortage of Portland cement due to the recent Korean War led the Corps concrete division to approve the usage of natural cement on the Eisenhower Lock resulting in honeycombing during construction and the discovery of structural problems following the first season of lock operations.

According to Robert Carpenter, an engineer on the project for the Corps, "The Corps dewatered the locks every year to make repairs. One winter Ken Hallock called me in Atlanta and wanted to know if I had known of any difficulty with the cement content on the Eisenhower Lock during construction. I knew the contractors had poured concrete on shifts when it was forty below zero, but since concrete gives off its own heat, I didn't think it would hurt its integrity. Once the concrete workers completed a five foot pour, they covered it with four foot bales of hay to keep the heat in. But the forms on the side couldn't be covered and that may have caused some scaling right on the surface."

Joe Marmo who had the longest tenure on the project starting as an office manager and finishing as a member of the claims department review team stated, "The Corps had originally designed the construction of the whole Seaway and Power Project to be completed in ten years. They were going to run this project in a very orderly fashion, but I don't know if they would have done any better. If the engineers had a longer time frame, the designs would have been done and evaluated prior to the commencement of construction. When you go into a project so unprepared, you risk the cost of change orders. We had tons and tons of changes and we had to negotiate each one of them with the contractors. The New York Power Authoirty settled the largest construction claim for $8 million with the Perini Corporation from Framingham, Massachusetts."

In addition to their annual concrete rehabilitation and maintenance program on the Snell and Eisenhower Locks, starting in 2009 the Seaway Development Corporation began a ten-year Asset Renewal Program. From 2011 - 2014 workers will complete the first phase of repairs including 41 projects involving lock rehabilitation and corrosion prevention on the Seaway International Bridge at a cost of $97.2 million. In the future, there may be a need to match the upgrades on the Canadian locks and channels, but under the existing plans there is no funding to expand the American locks or widen or deepen the channels.

Conclusion

At the July 9, 2009 Fiftieth Anniversary gathering commemorating the opening of the St. Lawrence Seaway in Massena, New York, speakers, dignitaries, and attendees acknowledged the fact that the St. Lawrence Seaway and Power Dam stands as the most impressive and continually operating bi-national waterway and power production facility. While Massena residents never witnessed the prosperity promised by promoters, the completed waterway allows ships to access the Great Lakes and the dam produces electricity for numerous towns and cities in the United States. The power facility will never cease operation; however, eventually the channels and locks will need to be expanded to remain viable.

James Romano, the owner of AJ Trucking, described the future of the waterway very poignantly, "The Seaway had many problems right after it was completed. Since there is only one lock for ships going both ways, this can create long lines and delays. It also takes about ten minutes for lock operators to raise a ship. Ship captains have to wait until the ship exits the lock before another can enter. At the time of the construction, the Corps of Engineers wanted to build additional locks and make it two ways, but they didn't have the money. Now engineers are talking about adding new locks that would be wider and longer because some of the ships are now scraping the sides and damaging the concrete. If they made it bigger today, depending on the size of the locks, the traffic on the Seaway could increase. I just don't know if the government or the environmentalists are willing to let that happen. The Seaway will probably crumble until it is useless before the politicians can agree on how to improve it."

Long Sault dam (left) during the construction of the Moses-Saunders power dam (right).

Making the Links: Pollution, Poverty, and Environmental Justice

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We have long known that our socio-economic success can often be predicted, in part, by the socio-economic status of our childhood neighbourhoods and that the provision of social services is linked to type of neighbourhood in which we live (Buzzeli 2008). Recently, however, a new lens has been added as researchers have begun exploring how the socio-economic status of our community affects our environmental health and new concerns are being raised about the issue of environmental justice.

Notion of Environmental Justice

The notion of environmental justice is inextricably linked to the notion of environmental racism in the United States. The term environmental racism, used since the 1980's, was described in the 1987 report Toxic Waste and Race in the United States, as the "intentional siting of hazardous waste sites, landfills, incinerators and polluting industries in areas inhabited mainly by Blacks, Latinos, Indigenous peoples, Asians, migrant farm workers and low income peoples." (Gosine 2008). It has also been described by scholars such as R.D. Bullard as "any policy, practice or directive that differentially affects or disadvantages (whether intended or unintended) individuals, groups, or communities based on race or colour." (Bullard 1996).

Acceptance of the concept of environmental racism has been met with resistance in the United States. Critics argue over its existence and its place in a discussion of environmentalism. However, in the last 27 years, research in North America has shown that non-white communities are faced with a disproportionate burden of environmental problems, have less say in the design and implementation of environmental regulations, and are less likely to have their contributions regarding the alleviation of environmental degradation considered (Gosine 2008).

When considering the notion of environmental racism, one must consider who pays for and who benefits from environmental and industry policies. Through industry's and government's choices, whether intentional or unintentional, environmental racism provides benefits for white communities while racialized communities bear industry's costs (Bullard 1996).

Environmental justice is "the broad goal that incorporates the more narrowly defined problem of environmental racism." (Bullard 1996). It links many social movements, including anti-racism movements, Aboriginal rights and sovereignty movements, labour union movements, and environmental movements. It embodies a broad concept of environment, moving beyond only green spaces and the wilderness, to include places that comprise everyday experiences (Bullard 1996). The hallmarks of environmental justice include access to information, early and meaningful public participation in environmental decision making and access to courts and tribunals.

Environmental Inequities in Canada

Colonialism, urbanization and the expansion of the natural resource economy have contributed to the disadvantage of specific populations including resource dependant communities, Aboriginal communities, low income and racialized communities, and biologically vulnerable communities (McClenaghan 2008). Canadian cities do not tend to have the same racial residential segregation as American cities. However, there are certainly low income areas in Canadian cities comprised of one or more racial groups. These low income areas are vulnerable in contrast to more affluent areas where residents are able to participate in decision making and to mobilize to protect their own interests.

Canada's economy has long benefited from our natural resources. Growth in the agricultural, forestry, fishery, oil and gas, mining, and energy sectors, has led to enormous growth for the economy and employment. As a result of this resource development, many small towns across Ontario, and indeed the country, have prospered. However, there is an environmental health legacy to be considered for these towns and their residents. The impacts to the local ecosystems, and the by-products which are often introduced as a result of industry, influence environmental health in the region. Additionally, there are often lasting impacts once the industry collapses and moves on and all too often the remaining communities have limited resources. Consequently, many communities bear an inequitable environmental health burden as a result of past and present industry practices (McClenaghan 2008).

Canada's history of colonialism has also left many Aboriginal communities facing severe environmental inequities. As colonization took place in Canada, many Aboriginal communities were pushed to areas which were considered to be less desirable to European settlers. As a result, Aboriginal communities now often suffer from "myriad toxic legacies placed upon them by centuries of (first) colonial oppression and (ongoing) post-colonial exclusion from the decisions and benefits of natural resource and industrial development which have occurred, in many cases literally, in their backyards." (McClenaghan 2008).

As noted previously, low income and racialized communities exist in Canadian cities. Generally, urban planning in Canadian cities over the 20th century has developed to benefit the middle and upper classes, while allowing some parts of cities to deteriorate. These deteriorated areas are often the areas most plagued by environmental problems such as high levels of air pollution and the presence of toxic Brownfield sites. They often lack urban amenities such as green space, easy access to nutritious food, walkable neighbourhoods and urban waterfronts. Unfortunately, these areas are also frequently called home for low income and immigrant groups who are struggling against ongoing socio-economic and racial exclusion (McClenaghan 2008).

Finally, a lack of recognition of the special needs of biologically vulnerable populations, such as the foetus, children, the elderly, and immuno-compromised individuals, contributes to environmental injustice in Canada. These vulnerable populations have a higher susceptibility to environmental stressors and as a result face a higher risk from environmental contaminants. For example, because of a child's small size, kilogram for kilogram of weight, a child breathes more air, eats more food, and drinks more water than an adult (Canadian Partnership for Children's Health and the Environment 2005). Thus, the impact of exposure to pollutants is greater in children. Additionally, studies have shown that the elderly carry a lifetime burden of exposure to environmental pollutants which leaves them more vulnerable to further environmental exposures (Health Canada 2008). Yet "these groups are not adequately protected under current environmental policies and are generally under-represented in Canadian standard setting and regulatory processes…. Further, there is presently little understanding of how biological vulnerability intersects with entrenched social inequities to exacerbate the overall magnitude of environmental injustices against these groups."(McClenaghan 2008).

One example of a project currently tackling the issue of environmental inequity in Ontario is "Environmental Health, Equity and Law: Making the Links." This is a three year project being undertaken by the Canadian Environmental Law Association and the Environmental Health Institute of Canada, with funding from the Law Foundation of Ontario. The project is founded on the recognition that vulnerable communities are disproportionately exposed to and affected by environmental contaminants. It uses an interdisciplinary approach - involving front line medical practioners, public health practitioners, environmental non-governmental organizations, legal aid clinics, occupational health advocates, community groups, and community members - in order to increase the level of engagement of community members in the legal system, enhance the communities' knowledge of legal tools, develop community skills, and to improve the capacity of front line workers to protect constituents from environmental threats to health. Project activities include public legal and medical education and partnerships that address a range of environmental health issues and concerns. There are six communities currently involved in the project, including Brantford, Cornwall, Hamilton, Kenora, Sarnia, and Windsor. Many of these communities were located on the Great Lakes basin for its transportation, water supply, cooling, and other related reasons. It is these communities which were largely part of Ontario's industrial centre which are now struggling with legacy issues and continuing issues of environmental health.

An Examination of Pollution and Poverty in the Great Lakes Basin

The study of environmental justice in Canada has been moving more slowly than in the United States. However, while the number of studies is small, it is growing.
Recognizing a gap in research, Pollution Watch partners, the Canadian Environmental Law Association and Environmental Defence, authored a study examining pollution and poverty in the Great Lakes basin. While the report was limited in scope (that is, it examined only reported industrial air releases and their relationship to income in the Great Lake basin) it has provided important results with respect to the relationship between pollution and social factors.

Table 1. Top 10 census subdivisions with the highest amounts of air releases of toxic pollutants in 2005 (kg) and the incidence of low income in economic families in 2001 (Pollution Watch)

Rank in Great Lakes basin	Name of Census Subdivision (CSD)	Province	Poverty Rate % in 2001	Number of NPRI Facilities that Report Toxics	Air Releases of Toxic Pollutants (kg) in 2005*
1	Greater Sudbury	Ontario	11.5	10	4,573,623
2	Haldimand	Ontario	6.3	7	3,010,746
3	St. Clair	Ontario	5.8	12	2,990,673
4	Sarnia	Ontario	11.3	8	2,837,269
5	Toronto	Ontario	19.4	150	2,819,466
6	Hamilton	Ontario	16.1	39	2,240,453
7	Mississauga	Ontario	11.3	71	1,653,908
8	Oshawa	Ontario	11.1	6	1,611,357
9	Thunder Bay	Ontario	11.1	11	1,216,208
10	Windsor	Ontario	13.2	30	1,007,380
	Total – top 10 CSDs			**344**	**23,961,083**
	Total all CSDs			**1,398**	**51,301,570**
	Top 10 as % of total			**24.6%**	**46.7%**

In the report, the authors note that both the US and Canadian governments have long recognized the need to address the high levels of pollutants in the Great Lakes basin, leading a number of initiatives to achieve that goal. Indeed, many communities in the Great Lake basin face a high pollution burden, each with unique challenges with respect to experience, resources, income and advocacy (Pollution Watch 2008).

The Pollution Watch report presented a number of important findings. First, more than one billion kilograms, or about 25% of total air pollutants reported in Canada, were reported being released to the air in 2005 in the Great Lakes basin. However, air pollutant releases varied widely across the basin, with some areas having much higher air releases than others. The ten areas in the Great Lakes basin with the highest air releases of toxic pollutants are all located in the Ontario portion of the basin (see Table 1).

Table 2. Census Subdivisions in the Great Lakes Basin with Poverty Rates at or above the National Average of 11.8% in 2001 and Air Releases of Combined Pollutants above 1 million kilograms from NPRI Facilities in 2005 (Pollution Watch)

Census Subdivision Name (CSDs)	Census Subdivision ID#	Air releases of Toxic Pollutants in 2005 (kg)	Air releases of Criteria Air Contaminants (CACs) in 2005 (kg)	Air releases of Combined (toxics and CACs) in 2005 (kg)	
Hamilton	3525005	2,240,453	58,459,377	58,788,549	16.1
Becancour	2438010	692,500	45,579,386	45,680,098	11.9
Rouyn-Noranda	2486033	101,871	27,212,078	27,313,949	12.3
Sorel-Tracy	2453052	30,500	25,695,946	25,716,304	14.1
Shawinigan	2436028	272,412	19,722,812	19,791,035	22.5
Montreal-Est	2466005	587,935	16,248,975	14,962,514	20.2
Sault Ste. Marie	3557061	364,495	14,439,101	13,845,095	13.5
Melocheville	2470060	107,697	9,461,000	9,542,697	15.0
Montreal	2466025	494,499	11,059,518	9,451,843	26.5
Saint-Romuald	2425025	168,128	8,573,863	7,981,183	14.5
Toronto	3520005	2,819,466	13,205,592	7,134,465	19.4
Windsor	3537039	1,007,380	8,412,711	7,023,209	13.2
Salaberry-de-Valleyfield	2470045	106,728	8,036,315	6,514,506	18.4
Trois-Rivieres	2437065	371,805	6,456,454	5,999,475	18.2
Joliette	2461025	29,113	5,757,456	5,703,089	19.2
Saint-Basile	2434038	299	5,340,980	5,320,299	13.2
Thurso	2480050	302,894	4,774,851	4,656,071	22.6
Espanola	3552026	311,826	4,510,685	4,505,528	15.6
Cornwall	3501012	642,468	3,512,262	3,334,161	19.0
Owen Sound	3542059	14,899	2,555,849	2,520,754	13.9
Grand-Mere	2436055	127,025	2,708,417	2,463,901	17.8
Quebec	2423025	186,085	2,521,992	2,310,802	22.1
Hull	2481020		2,200,378	2,184,401	18.0
Senneterre	2489040	24,030	1,683,788	1,636,618	21.7
Kirkland Lake	3554068	408	1,600,444	1,567,698	17.0
London	3539036	287,180	1,864,821	1,168,920	12.7
Lachute	2476020	39,693	1,016,983	1,039,762	19.3

After examining the reported air releases and the incidence of poverty in the Great Lakes basin, the report concluded that there are twenty seven areas in the Great Lakes basin, that have both high reported air releases of toxic pollutants and high poverty rates (see Table 2). People living in these areas may face a double challenge. That is, they face high potential for exposure to pollutants, as well as all the physical and social vulnerabilities that come from living in poverty.

The Pollution Watch study concluded that "there is a significant positive correlation between air releases of pollutants and poverty rates in census subdivisions in the Great Lakes Basin." As such, there is "a need to reduce both pollution and poverty, and to connect these efforts…. [T]here are still large amounts of pollutants being released from industrial facilities, and still large areas with high poverty rates. For some communities, these two challenges collide." (Pollution Watch 2008).

Conclusion

While in the United States there is recognition of the need to take account of environmental justice concepts in environmental decision making, in Canada there are no comparable policy requirements. Attempts to advance environmental justice concepts in decision making in Canada are still at very preliminary stages. Despite inclusion of cumulative impacts in Ontario's Ministry of the Environment's Statement of Environmental Values, no manual or guide to decision making yet exists and the extra burden on low income, Aboriginal, racialized, and other specific vulnerable communities has not been acknowledged as an important factor in Ontario's environmental decisions. As a result, for example, new air approvals continue to be granted in communities which suffer the double burden of very significant existing air pollution levels as well as low resources with which to respond.

It is imperative that decision makers on the Canadian side of the Great Lakes basin be required to take account of environmental justice considerations so as to begin to address these inequities and environmental burdens. As the U.S. Environmental Protection Act addresses its rule making, lessons should be extracted for Canada and elsewhere as to the efficacy of that approach and this should be the subject of further investigation.

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The struggle to balance environmental and economic interests on the Danube River

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The most international river basin in the world, the Danube basin is roughly twice the size of California and includes the territory of 19 countries. Flowing 2,780 km from Germany's Black Forest to the Danube Delta in Romania and Ukraine, and finally emptying into the Black Sea, the Danube is Europe's only major river that flows west to east, from Central to Eastern Europe.

In addition to its 81 million inhabitants, the Danube basin is home to a diverse system of natural habitats and species. More than 100 different species of fish – including six sturgeon species – call the Danube home, and it hosts globally-important and rare birds like the white pelican, white-tailed eagle and black stork.

The River's History

While large sections of the upper Danube in Austria and Germany have been regulated, the middle and lower Danube and the Danube Delta feature a highly rich and unique biological diversity that has been

Danube islands along the Bulgarian stretch of the Danube host a unique habitats and floodplain forests. Photo credit: Alexander Ivanov.

lost in most other European river systems. These floodplains provide multiple ecosystem services, such as water purification, nutrient sinks, natural flood protection, and fisheries and tourism.

The river is a principle resource for industry, agriculture, transport and power generation. Moreover, the Danube is home to some of Europe's last remaining ecological treasures; for example the lower, free-flowing stretch of 860 km with its biodiversity-rich islands, and the unique Danube Delta a UNESCO Biosphere Reserve.

As the case with many large river systems, the Danube has been much altered over the past 150 years from its natural state. Levees, dams and dredging have straightened large sections of the river. More than 80% of the Danube's wetlands have been lost, and with them some of the rich diversity of fish and other species on which they depend.

Nearly two decades have passed since the fall of the Iron Curtain. In that time, huge changes have swept the Danube region. The top-down control of Communist regimes has been replaced by a multiplicity of actors in politics, economy, environment and nature conservation. The region is being increasingly integrated into the global economy.

The sudden collapse of Soviet industry and agriculture did the environment good. Pollution suddenly dropped dramatically. Tougher environmental standards and massive investment in sewage and waste treatment became the norm, especially in the European Union's newest member states. The International Commission for the Protection of the Danube River (ICPDR) and EU legislation – in particular the Water Framework Directive – have given the world's most international river a framework for governance and integrated river basin management that is an example around the world.

Many former floodplain and wetland areas have been restored, demonstrating benefits not only for fishing, tourism and recreation, but also for flood and water management. WWF is working with decision makers to find ways to achieve large-scale restoration of Danube floodplains. In 2006, WWF published a working paper that shows how restoration of more wetland areas could significantly contribute to flood mitigation on the Danube, and just recently, an assessment of the restoration potential along the Danube and its main tributaries was released (www.panda.org).

Hence, after decades of abuse, the Danube has significantly recovered over the past twenty years. Today, the river is largely swimmable, and many of the worst environmental hot spots have been addressed. But while there have been notable successes for environmental protection, there are also many new and persisting challenges, including how to balance the economic and environmental "uses" of the Danube. One of the bigger challenges in WWF's eyes is safeguarding and re-establishing connectivity of the river – both longitudinal and latitudinal.

Plight of the sturgeon

It is not only the economic value of sturgeons, but also their place in evolution, fascinating life cycle and role as indicators of healthy ecosystems that motivate WWF to save the "giants of the Danube". As a result of man-made pressures, sturgeon populations in the Danube Basin have decreased dramatically during the past century. The dwindling number of sturgeon is at threat from navigation due to dredging and water infrastructure.

Figure 1. The construction of the dams had severe impacts on the distribution of sturgeon in the Danube River basin, limiting the migratory species to the Lower Danube. This map shows the past and present distribution of Beluga (Huso huso). Map credit: Fluvius, U. Schwarz (2005)

In past centuries, giant Beluga sturgeon the size of a dolphin migrated up the Danube as far as Germany. Dams – nearly 60 block the Upper Danube – have since cut off the sturgeon's migration routes. But the Iron Gates dams on the Danube between Serbia and Romania are the one barrier stopping sturgeon from migrating a full 2,000 km from the Black Sea up to Slovakia (Figure 1).

WWF has been working with the ICPDR and the governments of Serbia and Romania to examine options for making the dams passable to sturgeon and other species. A Sturgeon Action Plan was developed and adopted by the ICPDR, as well as endorsed by the Council of Europe and the Bern Convention, giving the Danube sturgeon priority for conservation on the river.

A basin-wide approach is vital for the success of any conservation or restoration measures for sturgeon. This includes requirements to re-open migration routes by enabling upstream and downstream passage at dams and other barriers to sturgeon movements, and at the same time taking measures to maintain or restore their spawning and feeding habitats. Such actions are required under the Water Framework Directive, and methodologies on how to prioritize this work have been agreed upon by Danube countries.

Unsustainable development

Despite these efforts, significant threats to sturgeon and the Danube's ecological well-being remain. One of the biggest threats today comes from EU and government plans to dike and dredge the river to allow for ever-larger ships.

Inland waterway transport (IWT) is one of the most important regional economic activities along the river. At the same time, IWT has been identified by the ICPDR as one of the primary causes of environmental degradation on the Danube.

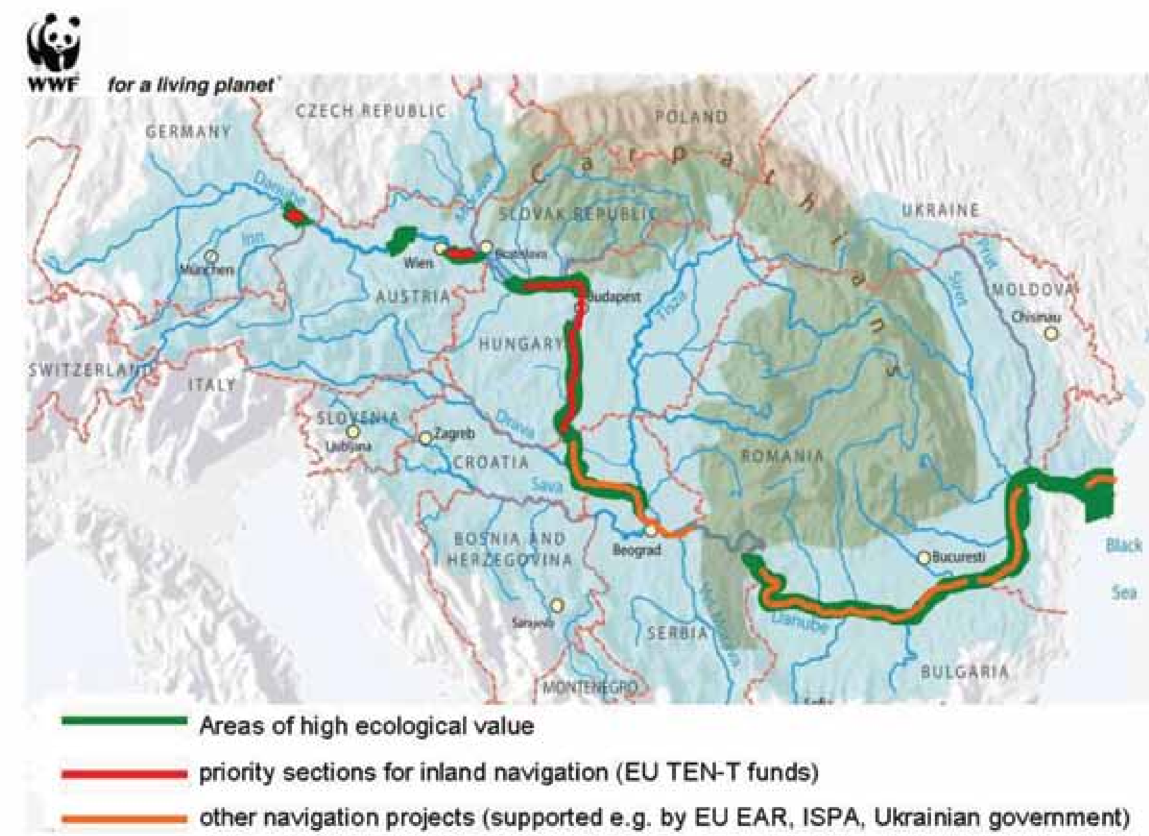

Figure 2. Economic (navigation) and environmental interests on the Danube River overlap. The remaining free-flowing sections of the river are highlighted in green. Credit: WWF (2009)

As part of the EU's Trans-European Transport Networks (TEN-T) program, new navigation infrastructure projects are planned that threaten many of the Danube's last free-flowing sections, and hence the most ecologically valuable areas. Valuable wetlands along 1,000 km of the river could face damage if these plans are realized.

WWF has been working on navigation issues in the Danube basin for the past decade. In December 2007, representatives of Danube governments, the European Commission, navigation lobbies and a small group of Danube advocates, including WWF, agreed to a common vision for environmentally sustainable navigation on the Danube (www.icpdr.org; Figure 2).

The first projects that are now moving forward provide little ground for optimism. A plan by the Romanian government to increase navigation between Calarasi and Braila would unnecessarily cut off the most important migration routes for Danube sturgeon and destroy highly valuable nature areas. Far from good practice, this project would set a bad precedent both for navigation as well as other projects funded by EU taxpayers.

Closer to being implemented are plans for a section east of Vienna in Austria up to the Slovakian border, which flows through the Danube Floodplain National Park. To many, this project represents a compromise between shipping interests and the environment, and includes deepening of the river channel as well as directing water to the floodplains of the national park, which have been slowly drying out.

The Ukrainian government started construction on another project of major concern, a navigation canal for large vessels that runs through the heart of the Danube Delta, Europe's largest remaining natural wetland. Despite protests and the canal being in breach of international conventions, the first phase of the project has already been implemented. If continued, the canal project will cause significant damage to the Danube Delta, both in the Ukraine and in Romania.

If shipping on the Danube is indeed to be promoted as an environmentally friendly mode of transportation, then there must be a balance between river protection and shipping along the entire stretch of the river. To date, however, there has been no strategic assessment of the impacts of planned projects on the Danube as a whole. WWF has been pressuring EU decision makers to complete such an evaluation before other navigation projects move forward.

Innovative solutions that promote IWT with less impact on the environment can be an alternative to infrastructure projects. For example, existing navigation could be significantly increased with "soft" measures such as improved logistics, modernized fleets, and river information systems for skippers without sacrificing the Danube's most valuable wetlands and benefits.

Conclusion

The Danube region has developed tremendously over the past two decades – from an environmental perspective, both for the better and for the worse. The world is heading towards an ecological credit crunch – according to WWF, human demands on the world's natural capital have reached nearly a third more than earth can sustain. This is just one of the many reasons we need to seek smart solutions that balance different uses of our rivers while preserving the essential ecosystems on which we all depend.

Links

www.panda.org/dcpo
www.icpdr.org

Ballast Water Management – current regulations and recent developments

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Current Regulations and Scientific Rationale

Ballast water is used to provide trim and stability to ships. Ballast water is also a pathway for the introduction of nonindigenous species into the waters of the Great Lakes. Ballast water regulations in the Great Lakes have undergone numerous iterative legislative steps and the current rules require all ocean-going ships to exchange their ballast tanks at sea and require saltwater flushing of every ballast tank containing residual amounts of ballast water and/or sediment. Therefore, every ballast tank on ocean-going ships entering the Great Lakes St. Lawrence Seaway System (GLSLSS) must maintain a salinity level of 30 ppt (parts per thousand).

These regulations are based on recent scientific research. A study by researchers from the University of Windsor, University of Michigan and National Ocean and Atmospheric Administration was one of the first controlled assessments of mid-ocean Ballast Water Exchange (BWE) on an ocean-going vessel operating between freshwater ports (Gray et al. 2007). They found that although there were freshwater organisms left in the tank after the BWE was conducted, the majority of these organisms were not viable after being exposed to open ocean water for a few days. Comparatively, studies to assess the effectiveness of BWE between saltwater ports found that these vessels had to rely solely on purging and dilution to eliminate coastal organisms. Vessels that ply the GLSLSS, from overseas freshwater ports and conduct BWE, have both dilution and salinity effects working to decrease the number of viable organisms in the ballast tanks. The result is that the viable organisms discharged from these vessels is below the number of organisms that the International Maritime Organization (IMO) has proposed as sufficiently protective for aquatic ecosystems (IMO 2004). These results from BWE also extend to the effectiveness of saltwater flushing, since like BWE, it also employs both dilution and salinity effects to lower the number of viable organisms in ballast tanks. Results from another University of Windsor study show that saltwater flushing, like BWE, leads to the reduction of the number of viable fresh-water organisms in ballast tanks (Bailey, Nandakumar and MacIsaac 2006).

Current Enforcement Regime and Results

One hundred percent of all tanks on all vessels entering the GLSLSS are targeted for inspection in Montreal. These Enhanced Shipboard Inspections are performed by a binational group of four agencies: Transport Canada, the U.S. Coast Guard, the Canadian St. Lawrence Seaway Management Corporation and the U.S. Saint Lawrence Seaway Development Corporation (Figures 1a and 1b). These agencies together form the Ballast Water Working Group (BWWG) which coordinates U.S. and Canadian enforcement and compliance efforts aimed at reducing the introduction of aquatic invasive species in the Great Lakes via ships' ballast water. Every year the BWWG prepares the Summary of Great Lakes Seaway Ballast Water Working Group , a document which is released by the U.S. Coast Guard (Ballast Water Working Group 2010).

Figure 1a. Ballast Water Working Group inspectors placing water from a ballast water tank onto a refractometer during an Enhanced Seaway Inspection. A refractometer is used to determine the salinity of a liquid by measuring its refractive index.

Figure 1b. A Ballast Water Working Group inspector using a refractometer to measure the salinity of the water from a ballast water tank.

In 2009, 100% of ocean-going vessels bound for the GLSLSS received a ballast tank exam. A total of 5450 ballast tanks, on board 295 vessels, were sampled and had a 97.9% compliance rate (Figure 2). Additionally, 100% of ballast water reporting forms were screened to assess ballast water history, compliance, voyage information and proposed discharge location. In 2009 Transport Canada issued seven Letters of Warning. A Letter of Warning is issued by the U.S. Coast Guard or Transport Canada when a vessel is found with discrepancies in its ballast water management plan, records or reports. It is used for minor first time offenses with a warning of possible assessment of a fine if not corrected. Ballast Water Working Group agencies issued a Letter of Retention for 53 vessels. Letters of retention are issued to vessels with noncompliant tanks that choose to retain the ballast water onboard the vessel. Verification boardings are conducted on every outbound vessel issued a Letter of Retention. In 2009 all vessels issued a Letter of Retention were boarded during their outbound journey and found to be in compliance. These inspections were tangible evidence that no un-managed ballast water or sediment was released into the GLSLSS from ocean-going vessels.

One point reiterated by all of the researchers evaluating the efficacy of current ballast water management measures, is that the success of the current regulations is directly linked to diligent enforcement. The Ballast Water Working Group anticipates continued high vessel compliance rates for the 2010 navigation season which opened on March 25, 2010.

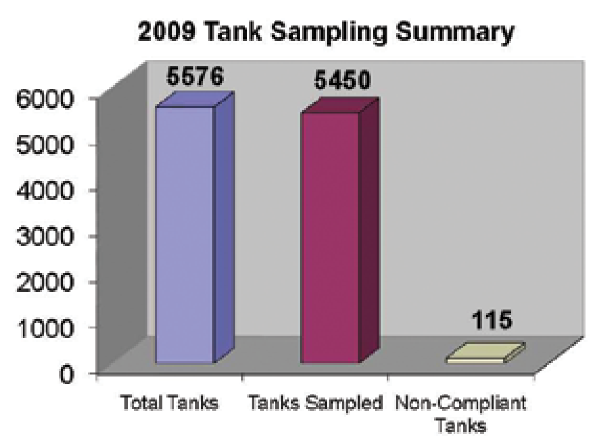

Figure 2. Summary of inspections of tanks on foreign-flagged vessels entering the Great Lakes during the 2009 season. Of the 5576 tanks, 5450 were physically sampled and 115 were found to be non-complaint. These 115 tanks were sealed and re-inspected during the outbound journey to ensure that the water was not discharged into the Great Lakes.

The Great Lakes Ballast Water Collaborative

The Great Lakes Ballast Water Collaborative (BWC) is an initiative to share relevant, useful, and accurate information and foster better communication and collaboration among the key stakeholders engaged in the effort to reduce the risk of introduction and spread of aquatic nuisance species. A particular emphasis of the Collaborative has been to bring state representatives together with marine industry representatives and respected scientists to find workable and effective solutions to the Aquatic Nuisance Species challenge as they relate to the Great Lakes St. Lawrence Seaway System. The aim of the BWC is not to take away from any pre-existing efforts in this regard, but rather to complement those efforts.

On September 24, 2009, the Great Lakes Ballast Water Collaborative held its first meeting in Detroit, Michigan, as an information-sharing forum on ballast water issues for the Great Lakes St. Lawrence Seaway System.

A second, BWC meeting took place on May 18, 2010, in Montreal, Quebec. A report of the Montreal BWC meeting can be found on the Seaway's bi-national website (Great Lakes Ballast Water Collaborative Reports) . The goal of this meeting was to focus on the informational needs of the Wisconsin Department of Natural Resources (WI DNR), as it prepares to develop a Ballast Water Treatment Technology Assessment Report, which is a requirement of the Wisconsin Pollution Discharge Elimination System (WPDES) permit. WI DNR must prepare its report by December 31, 2010.

The third, and most recent BWC meeting took place from July 20-21, 2010, in Duluth, Minnesota. This meeting provided an opportunity for attendees to visit Great Ships Initiative (GSI): the only fresh-water ballast water treatment system testing facility in the world, allowing them to gain a better understanding of the testing process/technology-verification procedures.

CCGS *Martha L. Black* of the Canadian Coast Guard fleet up bound on the St. Lawrence River.

This meeting also allowed the BWC to continue some of the detailed discussions carried out in Montreal. On July 20, the meeting focused on issues concerning testing and verification of ballast water and ballast water treatment systems, and included both a site visit to the Great Ships Initiative facility, as well as a "field" visit to a vessel calling on the Midwest Energy Resources Company terminal. On July 21, the discussions of testing and verification continued and the three working groups that were created at the Montreal meeting to assist WI DNR with their technology assessment had an opportunity to meet and discuss their specific topic. As with the first two BWC meetings, a wide variety and number of participants were in attendance.

Summary

Current ballast water regulations on the Great Lakes are scientifically-based. These regulations are enforced by four agencies that form the Ballast Water Working Group (BWWG): Transport Canada, the U.S. Coast Guard, the Canadian St. Lawrence Seaway Management Corporation and the U.S. Saint Lawrence Seaway Development Corporation. In the meantime, the landscape of ballast water regulations on the Great Lakes is constantly changing, and the Great Lakes Ballast Water Collaborative is an initiative designed to facilitate adaptation by the maritime industry as states are added to the list of ballast water regulators.

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Coastal wetland integrity in the upper St. Lawrence River: status and considerations for restoration and enhancement

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Introduction

Coastal wetlands provide critical services to the St. Lawrence River ecosystem and the communities that depend upon it. These extensive wetlands are instrumental in the pelagic-littoral coupling in the river food web and downstream transport organic matter and essential nutrients while providing critical habitat to a multitude of both migratory and more sessile aquatic organisms. Throughout the Great Lakes, coastal wetlands are known to directly influence reproduction of most fish species (Jude and Pappas 1992) imparting a direct linkage to the economics of sport fisheries as well as biodiversity as a whole. Despite the known value of coastal wetlands, the Great Lakes have lost over 50% of their original wetland area, Lake Erie alone has lost >90% and Lake Ontario has loss over 50%, primarily to land conversion (Whillans 1996). In the upper St. Lawrence River the area of wetland area lost is not known but is likely considerable. Of additional concern, however, are losses of ecological integrity in the remaining wetlands as a response to anthropogenic change.

In order to begin to address this concern, an understanding of wetland successional forces and potential impacts of human activities (e.g. land use, water level regulation, and invasive species) must be developed. The intent here is to consider wetland integrity of the upper St. Lawrence River wetlands in the context of the existing knowledge base. Significant advances have been made in our understanding of wetland processes of Lake Ontario and the St. Lawrence River due to the recent IJC water levels study (IJC). This information and other studies of St. Lawrence and Lake Ontario wetland systems will be reviewed to address the question of status of extant coastal wetlands in the upper St. Lawrence River.

Understanding Coastal Wetland Succession

Wetland succession can be affected by both autogenic (internally-driven) and allogenic (externally-driven) processes. Paleoecological studies based on peat and sediment cores provide information on past biota and depositional environments and allow inferences about the basic forces driving wetland successional processes. Changes in sediment properties (e.g. total organic carbon [TOC], total organic nitrogen [TON], bulk density, isotopic composition) coupled with analysis of biotic indicators such as pollen and macrofossils can provide a detailed picture of changes in the physical / hydrological environment and plant community of a wetland over millenia. A recent wetland paleoecological study was completed from a Goose Bay 10-meter sediment core representing a period of 10,500 years. Using pollen and macrofossil analysis as well as sediment δ13C, δ15N, and C:N ratios, past vegetation communities were reconstructed (Rippke et al. 2010). Evidence of the Nipissing Flood between 5200-4500 YBP was provided by a +8‰ shift in 13C, a concomitant persistent anomaly in organic matter, and depressed C:N ratios. Climate cycles, 3300 years in duration, were inferred from >50% shifts in grass (Poaceae) pollen abundance. An 80% increase in invasive cattail pollen occurred abruptly around 1894 AD following European settlement and land clearing (Rippke et al. 2010). This study and others in the Great Lakes basin reveal that changes in water depth due to climate cycles and the opposing forces of isostatic uplift and vertical sediment accretion regulate long-term succession of Great Lakes/St. Lawrence wetlands (McCarthy and McAndrews 1988, Dalrymple and Carey 1990, Duthie et al. 1996, Booth et al. 2002).

Disturbances in the upland matrix surrounding wetlands may strongly influence succession by increasing erosion and sedimentation rates, reducing wetland microtopography (Werner and Zedler 2002), and favoring plants that tolerate burial (Jurik et al. 1994, Keddy 2000, Kercher and Zedler 2004). Like other paleoecological studies in the Great Lakes region (Singer et al. 1996, Warwick 1980), Rippke et al. (2010) show that disturbances associated with European settlement and land use caused particularly rapid and substantial changes in the rate and trajectory of St. Lawrence River wetland succession in recent centuries.

Evidence for Recent Perturbations and Wetland Change

Climate affects Great Lakes wetland vegetation dynamics on the scale of decades by controlling regional water level dynamics (Chow Frazer et al. 1998, Wilcox and Xie 2008). Cyclical periods of high water exclude trees and shrubs from St. Lawrence and Great Lakes marshes, and periods of low water allow recruitment of a diverse assemblage of wet-meadow and mud-flat species from the seed bank (Keddy and Reznicek 1986) while eliminating or reducing drought-intolerant *Typha* species, which may be pushed to lower portions of the elevation gradient (Wilcox et al. 2008). Without periodic low water periods, increased growth of *Typha* species in the meadow marsh zone is common, and may lead to reduced plant diversity (Wilcox et al. 2008, Vaccaro et al. 2009, Farrer and Goldberg 2009).

Several recent studies have documented vegetation community change over the preceding five or six decades in upper St. Lawrence River wetlands using historical aerial imagery interpretation (Wilcox et al. 2008, Cooper et al. 2008, Farrell et al. 2010). A common feature of each interpretation is the reduction of meadow marsh type habitats dominated by a native sedge community. Wilcox et al. (2008) go further by showing evidence of an upslope migration of meadow marsh, and suggest that these changes are effects of system-wide water level regulation. Concurrently, it appears that the hybrid cattail (*T. x glauca*), a cross between native *T. latifolia* and *T. angustifolia* (invasive) has expanded into former meadow marsh areas. Water depth increases and a lack of substantial low-water periods observed in recent decades have likely facilitated growth and expansion of hybrid cattail (Farrell et al. 2010).

Current Status of Vegetation Communities and Linkage to Indicator Faunal Habitat

Among wetland geomorphic types that include drowned river mouth wetlands, open and protected embayments and along tributaries, high densities of invasive cattails predominate, and cattails continue to spread at the expense of other types of wetland vegetation. Stem densities can exceed 30 stems per m^2 and the thick litter layer produced in dense stands changes rates of nutrient cycling (Farrer and Goldberg 2009), inhibits germination and growth of native species (Vaccaro et al. 2009), and may fundamentally

change the response of wetland vegetation to further water level fluctuations (Frieswyk and Zedler 2006, 2007). Studies of the competitive effects and water depth tolerance of hybrid cattail suggest that it will likely continue to outcompete other vegetation types along the wetland elevation gradient. Today expansive cattail monocultures are common across most wetland geomorphic types in Lake Ontario and the upper River.

In addition to the widespread dominance of freshwater coastal marshes by hybrid cattail, other invasive species are having transformational effects on wetlands. Populations of common reed (*Phragmites australis*), purple loosestrife (*Lythrum salicaria*), and flowering rush (*Butomus umbellatus*) all exist within these coastal wetlands and have potential to expand and further outcompete native species. Significant expansion of reed canary grass (*Phalaris arunduleaca*) has already occurred in many wetlands in headwater areas influenced by beaver, and European frogbit (*Hydrocharis morsus ranae*), a floating leaved invasive, dominates in most drowned river mouth wetland habitats and extends into the *Typha* mats.

Despite the rapid and extensive changes produced by invasion of *T. x glauca* and the negative effects from other invasives, some high quality native habitat does still exist in upper St. Lawrence wetlands. Remaining meadow marsh communities are severely restricted but occur in a narrow band upslope of the dense *Typha* zone. Remnant meadow marsh areas also occur in locations with a stronger influence of local hydrology, including headwater streams, beaver flowages and groundwater dominated areas. Further downslope of the *Typha* zone near the open water edge there sometimes is greater plant diversity with a variety of forbs, the grass *Calamogrostis canadensis* and a littoral zone consisting of floating leaved plants (e.g *Nuphar and Nymphaea*) and submersed plants including *Utricularia vulgaris, Ceratophyllum demersum* and *Myriophyllum* species. Interestingly many tributaries and drowned river mouths have shown a recent resurgence in southern wild rice (*Zizania aquatica*). This deep-emergent grass has cultural significance to native peoples and is valued as an excellent food source for wildlife (Steeves 1952). Z. aquatica inhabits slow-flowing waters up to approximately 1 m in depth (Bean 1909), existing as a narrow bladed submergent or floating-leaved plant early in the growing season and then emerging to set seed from a tall slender panicle in late summer (Steeves 1952).

A variety of animals species are linked with wetlands in this region, recent studies on vertebrate species include marsh birds (Rehm 2004), herpetofauna (Jensen 2004) mammals (Toner and Farrell 2010), and fish (Murry et al. 2007, McKenna et al. 2008). Two of the indicators reviewed here include a fish and mammal that have critical influences on the ecology of the St. Lawrence River, muskrat and northern pike.

Historically, St. Lawrence River northern pike were known to make large early spring potadromous spawning runs to reach seasonally flooded wetland habitats areas for spawning. Research has documented an unusual deepwater spawning trend (up to ~6 m) for northern pike in the St. Lawrence River system that may be linked to declines in recruitment (Farrell 2001). Spawning distribution of northern pike is controlled by habitat presence, access to suitable substrates (due to springtime water levels), and thermal regimes (Farrell et al. 2006). Farrell (2001) demonstrated a spatial and temporal transition of northern pike spawning from shallow flooded habitats to deeper offshore habitats at Rose Bay in the St. Lawrence River. Local northern pike year class failures occurred, with high levels of deepwater egg deposition.

Changes in the vegetation structure of historical spawning sites (tributaries and flooded shorelines), to habitats dominated by species such as Typha, that are not preferred for spawning, as well as the effects of system-wide water regulation may have contributed to lack of northern pike population recruitment and recent declines.

Typha marsh is known as a critical habitat linked to the life history of muskrat (*Ondatra zibethicus*) and *Typha* is a favored species for forage and mound construction. Muskrats are known as ecosystem engineers for their strong effect on wetlands through influencing vegetation structure, microtopography, and decomposition of litter. Recent research however, points to water level regulation as a major factor regulating the abundance of muskrat in upper St. Lawrence River coastal wetlands (Toner et al. 2010). Low fall and winter water levels prevent access to the floodplain for overwintering water levels and a model analysis indicated the muskrat house density has been significantly suppressed relative to that predicted with unregulated levels.

Potential for Restoration and Enhancement - Anticipated Wetland Ecological Benefits of a New Regulation Plan

The 1993 Lake Ontario Lake Levels Reference Study began to bring into question the role of water level regulation effects on environmental considerations. Under the current regulation Plan 1958D, no formal consideration of the environment exists in water level policy. The influence of regulation on wetlands was a primary emphasis in the most recent St. Lawrence River- Lake Ontario Water Levels Study and IJC regulators are attempting to craft a new regulation plan that could balance the many interests (e.g hydropower, navigation, riparian interests, municipal water supplies, recreation, and other public interests) with consideration for environmental integrity (IJC 2005).

The study led to development of an Environmental Ecosystem Response Model (LimnoTech Inc.) to assist the IJC decision making process. The IERM contained 32 environmental indicators developed by an integrative group of researchers, the Environmental Technical Working Group. Many of the indicators revolved around those developed for wetlands in the upper River and Lake Ontario. Research toward development of a meadow-marsh indicator (Wilcox and Xie 2007) provided a sensitive indicator of long-term decadal scale effects of regulation plans changes on the movement of plant communities associated with wetland zonation. Regulation has prevented significant low water levels during the growing season that historically occurred every 30-35 years and has forced wet-meadow (sedge dominated) habitats further upslope into drier conditions. A restoration of hydrologic conditions to more closely approximate natural conditions of flow magnitude, duration and periodicity would be expected to create a greater diversity of wetland vegetation types and provide greater access and habitat features for important wetland fauna. These periodic lows would allow for seed bank responses by native species that have been suppressed (*Carex* spp.) and would select against invasive *Typha x glauca* (Farrell et al. 2010). More research is needed to demonstrate how these changes in regulation would influence the spread of invasive species, most notably common reed (*Phragmites australis*), which is known to outcompete *Typha x glauca* and has expanded in the drought conditions of the upper Great Lakes.

Further downstream in fluvial lakes of the St. Lawrence River in Quebec a two-dimensional hydrodynamic model has been developed (Morin et al. 2003) and integrated with continued ecological models useful in policy development and environmental projections (e.g climate change, water levels policy). This approach that focuses on the physics of the system as a basic building block may provide a useful model that could be applied to the entire system when coupled with ongoing monitoring and research as an adaptive management tool.

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Wetlands along the New York shoreline in the Thousand Island region.

On Scientific Efforts Concerning the International Section of the Saint Lawrence River

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With an average annual discharge of 9,850 $m^3 \cdot s^{-1}$ at its entry into the St. Lawrence Estuary, it is the largest fluvial point source of fresh water to the North Atlantic Ocean. An assessment of North American rivers classifies the St. Lawrence River as continentally outstanding and endangered (Abell et al. 2000). It is the only natural drainage of the Laurentian Great Lakes, the source of 20% of the Earth's surface fresh water in a watershed that is home to 33 million people in the United States and Canada (USEPA and Govt. of Canada 2002). The International Section of the St. Lawrence (ISSLR) is the portion of the river from its headwaters at the outflow of Lake Ontario to where the river enters fully into Canada, downstream from Massena, New York (Fig. 1). The ISSLR contains a portion of the Canada –United States border along its length and thus, it is a jurisdictional component of the Great Lakes (International Joint Commission 1994). Average annual discharge over the period of 1900 to 1995 in this reach of the St. Lawrence River is 6,910 $m^3 \cdot s^{-1}$ (USGS Station 04264331) ranking it alone as the 3rd largest river in North America after the Mississippi and Mackenzie rivers.

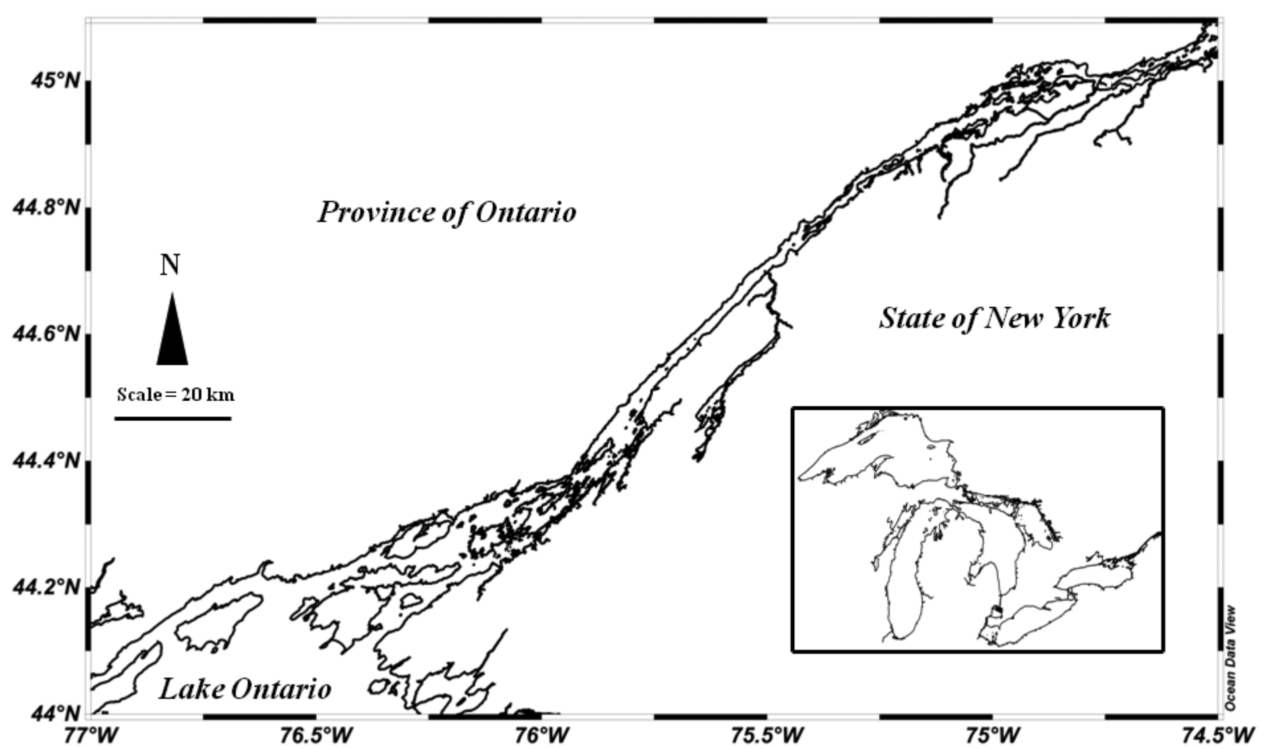

Figure 1. International Section of the St. Lawrence River.

The magnitude and complexity of the St. Lawrence River is a challenge to limnologists seeking to probe its hydrology, ecological organization, and function. Only 4% of river research has been conducted on rivers having a discharge of >100 $m^3 \cdot s^{-1}$ (Kalff 2002). There are distinct needs for large river science that are driven by the fact that almost all major North American Rivers are impacted directly by human activity, they have a wide range of uses (e.g., transportation, source water, waste water disposal, transportation, hydroelectric power, recreation) – this is particularly true for the St. Lawrence River (Vincent & Dodson 1999). The St. Lawrence River is a focal point for research and management in the Province of Quebec where it is the predominant geographic feature in the heartland of the province (see Hudon 2011, this issue). Accordingly, the reach of the river within that province has benefited as the subject of comprehensive reports on its status and threats (SLC 1996a, SLC 1996b). However, in relation to other components of the Great Lakes-St. Lawrence River system, the ISSLR has received little attention; the reason for this paucity of scientific investigation seemingly stems from the low US and Canadian population in the ISSLR region(Twiss 2007). In turn, this neglect becomes an environmental justice issue (see Griffin and McClenaghan 2011, this issue) that creates a hindrance to the research required as an integral component of environmental governance.

The ISSLR had been eyed for its hydroelectric power generation and power generation potential for over 100 years. The Canada-United States Boundary Water Treaty of 1909 specifically addresses such issues as impoundment, flood control, diversions, establishment of canals and rights of way in order to deal in part with the inevitable engineering of this waterway. Accordingly, water levels in the river have been monitored for over 100 years, discharge is well characterized, as is the geology of the region as needed for hydropower dam and canal construction. However, there is a detachment between understanding and ability to model hydrologic processes and that needed to do the same for ecological processes in this same system; this is due to a lack of interdisciplinary approach to modeling large river systems. In a report by the Water Environment Research Foundation on a review of large river priority needs, the effects of flow regimes on ecological processes is considered a key research need (Lippencott 2005), one that is considered by this author to be the most important overriding factor affecting ecosystem integrity in the ISSLR.

Water levels in the ISSLR are managed closely by control of discharge at the Moses-Saunders power dam. The Water Control Board of the International Joint Commission is responsible for maintaining water levels in order to ensure adequate potential for maximum hydroelectric power production, to prevent downstream flooding, to ensure adequate water depth in the Port of Montreal and navigation in channels in the ISSLR, and to stabilize the for ice pack in the ISSLR above the dam during winter. Water levels and their variations are essential to most river ecological issues, which are described briefly herein.

Information of the fishery in the ISSLR is scant (Busch and Patch 1990) compared to other areas of the Great lakes or in downstream reaches of the St. Lawrence, yet some information (albeit limited) is available from pre-dam construction era (see New York State Conservation Department 1931). The US Fish and Wildlife Service include the ISSLR in its atlas (Goodyear et al. 1982) and the Great Lakes Fishery Commission has conducted surveys to assess the ISSLR fishery as part of its Lake Ontario assessment. Monitoring work and research conducted at the Thousand Islands Biological Station operated by SUNY-College of Environmental Science and Forestry has made numerous recent studies of fish populations, including the charismatic muskellunge (see www.esf.edu/tibs/Publications.htm). Power dam operation, however remains a threat to fishery stocks through ecotone encroachment of wetlands (see Farrell and Distler 2011, this issue), and the continual mortality of migratory fish such as the American eel through turbines (De Lafontaine et al. 2010). Wetlands in the ISSLR are among the most diverse within the Great

Lakes Basin yet are in a deteriorating condition due to water level stabilization that allow for emergent macrophytes to invade submerged aquatic vegetation (SAV) meadows thereby reducing the extent of SAV and concomitantly, biodiversity (SOGL 2009).

Fisheries are ultimately supported by the lower food web of aquatic ecosystems. Both the Ontario Ministry of the Environment (OME) and the New York State Department of Environmental Conservation (NYSDEC) make routine measurement of water quality in the ISSLR in municipal water intakes and standard collection sites, e.g. the Rotating Integrated Basin Studies (RIBS) of the NYSDEC. The RIBS program also conducts water quality assessment using macroinvertebrate indices, although the number of sites limits a comprehensive assessment of the ISSLR and the use of stations in the main channel of the ISSLR (e.g. on navigational buoys) stretches the interpretation of these assays, which were developed and refined on smaller order streams. Research on lower food web and environmental contamination in the ISSLR can be found in special issues of the journals *Canadian Journal of Fisheries and Aquatic Science* (Lean 2000) and *Hydrobiologia* (Marty et al. 2010); however ecosystem-based management requires additional more comprehensive studies along this vein. Contaminants in the ISSLR are monitored though the NYSDEC at the RIBS monitoring station at the Moses-Saunders power dam and also by Environment Canada at the Wolfe Island monitoring station at the mouth of the ISSLR, which has collected data since 1976.

From a biological and biogeochemical perspective long term data sets and the analyses they enable are essential to ecosystem management. For example, OME water intake data from Brockville, ON illustrate the impact that dreissenid mussels have had on the ISSLR water quality (Nicholls 2001), and data from the Thousand Island Archipelago (Farrell et al. 2010) over 30 years shown marked ecosystem change related to change sin nutrient loading and invasive species impacts.

Although there is scientific research being conducted on the ISSLR and some monitoring activity, there remains a need for more information to support management requirements. In the 1950s there was no environmental impact assessment conducted for the construction of the St. Lawrence Seaway and the hydroelectric power project. Thus, our current assessment of ecological status requires a post hoc analysis that is even more difficult considering the last comprehensive ecological survey was conducted over 25 years ago. The ecological survey conducted by the USFWS in the ISSLR (Patch and Busch 1984) concludes that the lack of precedent status makes evaluation difficult since the precedent condition was unknown.

The lack of precedent or reference condition are also required for responsible assessment of beneficial use impairments in the two Areas of Concern located in the ISSLR (see Bheeler and Ridal 2011, this issue). Paleolimnological approaches can be used to establish reference conditions but this approach is challenging in a large river environment (Reavie and Smol 1997). Hydraulically-driven modeling (deterministic-empirical) efforts may prove a useful approach for reconstructing what the river ecology may have been like prior to profound changes in ecosystem function resulting from impoundment by the Moses-Saunders and Long Sault dams, high nutrient loading (during the 1960s), and invasive species (dreissenid mussel invasion in the 1990s). One strong criticism of the case for changes in existing water level regulations by the Lake Ontario St. Lawrence River Study (International Lake Ontario Study Board 2006) is the lack of understanding how changing water level regimes would affect lower food webs (Wescoat et al. 2006).

Given expected changes in water discharge through the ISSLR that will occur with climate change

(Crowley 2003), and the effects on water level regulation capacity and ecological functioning, as described above, it is clear that coordinated study of all aspects of the ISSLR ecosystem is required so that future gaps in knowledge of the ISSLR will be avoided.

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Cape Vincent, New York at the head of the St. Lawrence River viewed from the USEPA vessel R/V *Peter Wise Lake Guardian.*